A Regional Modeling Study of the South China Sea with High Resolution Hydrostatic and Nonhydrostatic Nested Models of the Luzon Strait

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LONG-TERM GOALS

The goal of this work is to better understand the generation, propagation, modal transformations and interaction of multiple Nonlinear Internal Waves (NLIWs) on the continental slope and shelf using nonhydrostatic models embedded in nested hydrostatic models with *realistic forcing* and *bathymetry*. Accuracy will be assessed by hindcasting and forecasting the temperature, salinity and velocity fields for the SCS (South China Sea) north and east of Dongsha island and comparing the results with data from the experiments of this DRI and from the ASIAEX experiment.

This work will provide the understanding needed to build an operational system to predict the timing, location and intensity of NLIWs as required for tactical planning.

OBJECTIVES

- To identify the mechanisms responsible for the generation, propagation, fission, interaction and modal transformations of NLIWs on the slope and the plateau north and east of Dongsha Island in the SCS
- To hindcast these NLIWs using high resolution nonhydrostatic and hydrostatic numerical models with realistic ocean topography and surface forcing and using open boundary conditions provided by the large scale ocean model.
- To determine the space and time scales involved in these processes that influence NLIWs on the continental shelf and slope of the SCS and their relationship to local and remote forcing.

APPROACH

We have used the nonhydrostatic (NRL-MIT) modeling system embedded in a system of multiply nested hydrostatic Navy Coastal Ocean Model (NCOM) models. The NRL-MIT system consist of the nonhydrostatic version of the MITgcm model wrapped in a suite of scripts that provide initial fields and open boundary values from the NCOM model and handle restart and output in a series of segmented, parallelized integrations that maximize cpu usage and the ratio of system to wall clock time. The forcing consists of surface fluxes from the Coupled Ocean Atmosphere Prediction System (COAMPS) and the Navy Operational Global Atmospheric prediction System (NOGAPS) operational nowcast/forecast system and open boundary conditions from the global NCOM forecasts. The basic

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bathymetry is the NRL DBDB2 (2 minute) bathymetry which has been enhanced and improved with several additional bathymetry databases provided by our Taiwanese collaborators. The hindcasts are done at increasing resolution using additional nested domains.

WORK COMPLETED

We have constructed the DongSha Plataeu 1/800th degree hindcast domain (DSP800). This is a high resolution nonhydrostatic hindcast domain with O(125 m) resolution spanning 20.7N to 21.3N and 116.7E to 118.0E (Figure 1b). There are approximately 1040 points in longitude and 480 points in latitude with 35 points in the vertical for a total of 17,472,000 points. This domain is initialized and forced with data from the DSP200 domain (Figure 1b)which spans 20.5N to 21.5N and 116.5E to 118.5E at approximately 500m resolution (2,400,000 grid points).

The DSP200 nonhydrostatic domain is initialized and forced with data provided by Dr. Ko from the hydrostatic LZS64 (Luzon Straits) domain (Figure 1a, b) which is hydrostatic with a resolution of approximately 1.5 km. The LZS64 domain is initialized and forced with data from the EAS16NFS (East Asian Seas Nowcast/Forecast System) hydrostatic domain (Figure 1a). That domain is part of the NRL Global NCOM nowcast/forecast system.

The 1/8° global NCOM is run daily at the Naval Oceanographic Office (NAVOCEANO) with atmospheric forcing from the Navy Operational Global Atmospheric Prediction System (NOGAPS) and assimilation of SST and synthetic temperature and salinity profiles via the Modular Ocean Data Assimilation System (MODAS) climatology based on input from the operational 1/16° NRL Layered Ocean Model (NLOM) SSH and 1/8° MODAS 2D SST nowcasts. Real-time results from global NCOM and EAS16NFS can be found at http://www7320.nrlssc.navy.mil/global_ncom and http://www7320.nrlssc.navy.mil/EAS16_NFS respectively.

The DSP200 domain is composed of 348x200x35 = 2.4mil grid points. The hindcasts used 120 processing elements (PEs), generated 5 GB of data per simulation day and used 72 processor hours per simulation day. Additionally the DSP800 domain is composed of 1040x480x35 = 17.4mil grid points. The hindcasts used 664 processing elements (PEs), generated 7 TB of data per simulation day and used 8500 processor hours per simulation day.

RESULTS

Hindcasts with the DSP200 domain show NLIWs with large amplitudes and three dimensional nature. However, hindcasts in the DSP800 domain produce a much richer, more complex three dimensional field of large amplitude nonhydrostatic NLIWs. The vertical structure of the NLIWs is better defined, the amplitudes are larger. We have begun to look at the statistics of the waves that develop in the DSP800 domain. In particular we looked at a longitudinal section at 21°N. We have identified 26 ISWPs from April 1, 2005 to April 29, 2005. On average a wave packet had 5 identifiable waves. Although a few wave packets had 12 waves. The average packet velocity was 1.1 m/s westward. The average amplitude was 57m and the half-width was 910 m. We are comparing these statistics with field observations. The initial qualitative comparisons of individual waves are very good (Figure 2).

A recent analysis of field observations at three mooring locations along 21°N was based on the characteristics of waves that were observed at all three moorings. However, we find that the majority of waves do not propagate through all three moorings. Also there is significant horizontal variability to the NLIW field with waves traveling in many directions (Figure 3). We have many examples of waves propagating through the moorings from oblique angles, not just from the east

The hindcast also generates mode 2 NLIWs (Figure 4) which have been observed rarely in this region. They are more common further west on the continental slope.

IMPACT/APPLICATIONS

This work will help to determine the importance of and the requirements for nonhydrostatic forecast systems for naval applications. The scales and features which will require nonhydrostatic simulation are being assessed.

RELATED PROJECTS

The NRL project Autonomous Characterization of Environmentally Induced Non-Acoustic Noise and the Adaptation of Multi-Sensor USW Networks. (6.2, Undersea Warfare) is related to this project because it involves nonhydrostatic modeling of the SW06 experimental area and time and comparison with measurements taken during SW06. Components of SW06 are funded through this ONR NLIWI DRI.

—Results have been transitioned to

—ACOMMS Performance in Turbulent Layers (6.2)

—Effects of Non-Acoustic Noise on Multi-Sensor USW Networks (6.2)

—The follow on project is

—Nonhydrostatic hindcasts of Internal Wave Generation in Straits (IWISE)

—This work is supported by the HPC project

—Nonhydrostatic Modeling of Nonlinear Internal Waves and Turbulence

PUBLICATIONS

In preparation.

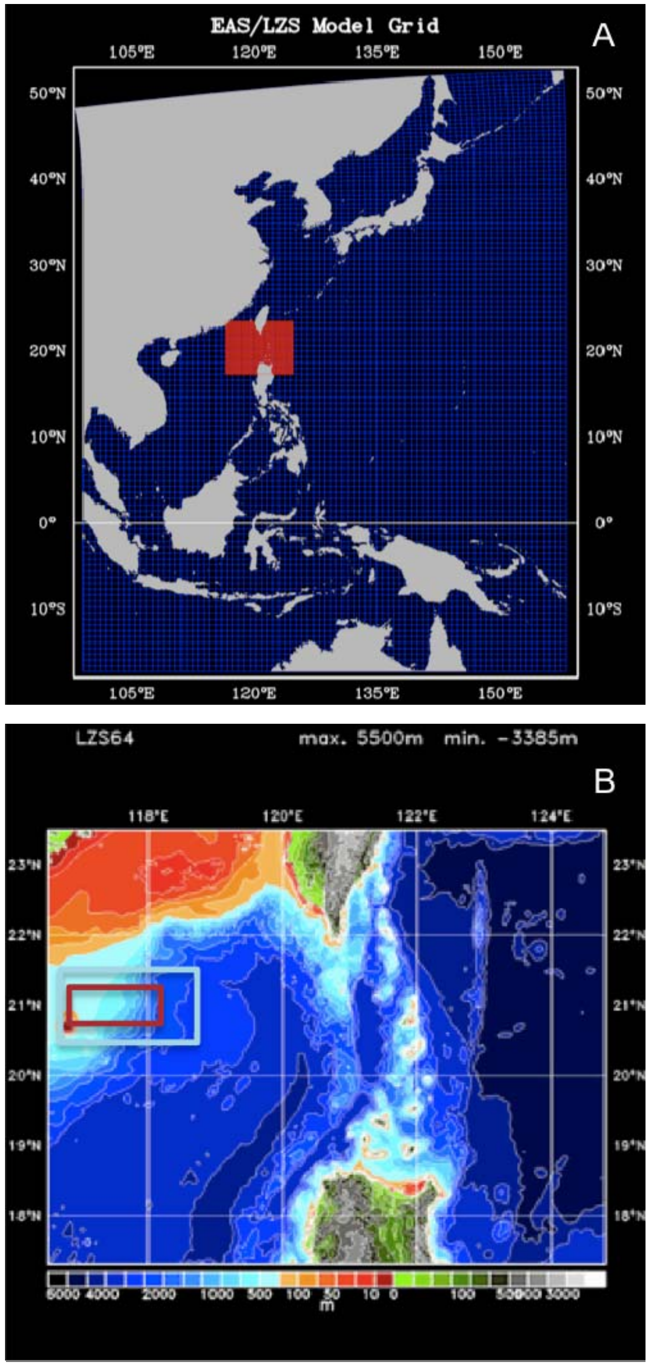

Figure 1 . 1A is the EAS16NFS. The red square inside 1A is the LZS64 domain. 2A is the LZS64 domain. The red rectangle is the DSP800 domain inside the DSP200 domain (blue rectangle).

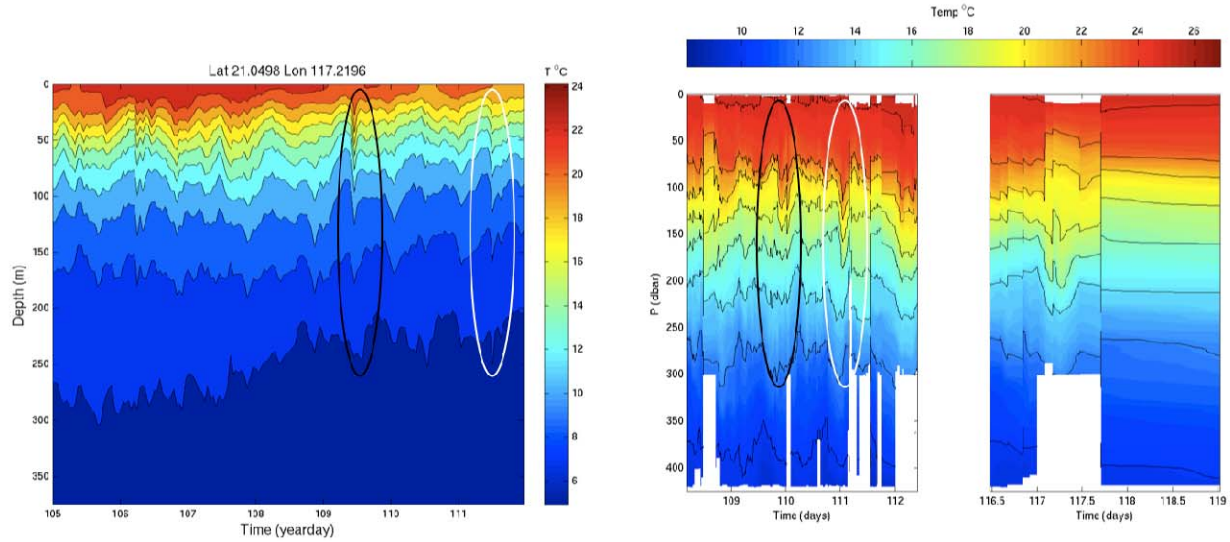

Figure 2. Comparison of hindcast NLWIs and historical observations at (21.05°N, 117.2°E).

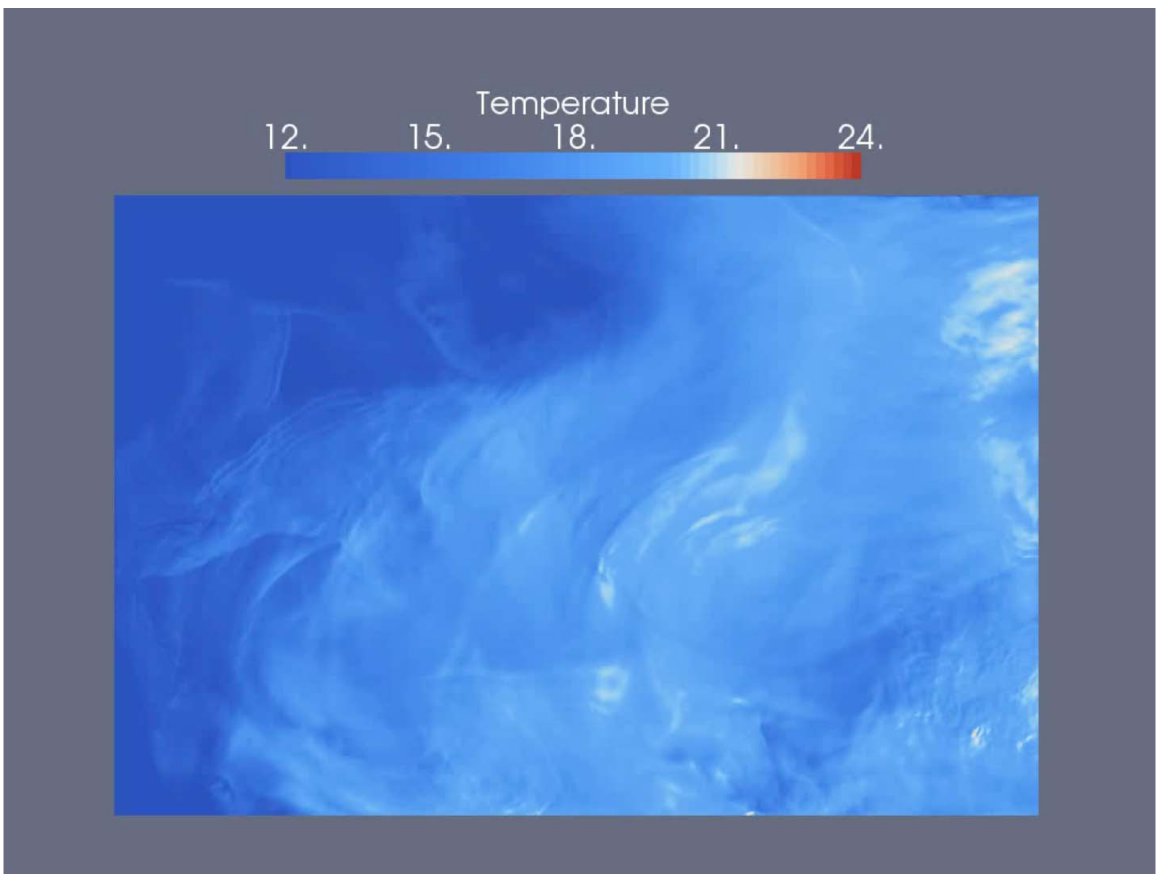

Figure 3. Plan view of temperature showing the rich variety of the shapes and directions of the NLIWs and submesoscale structures.

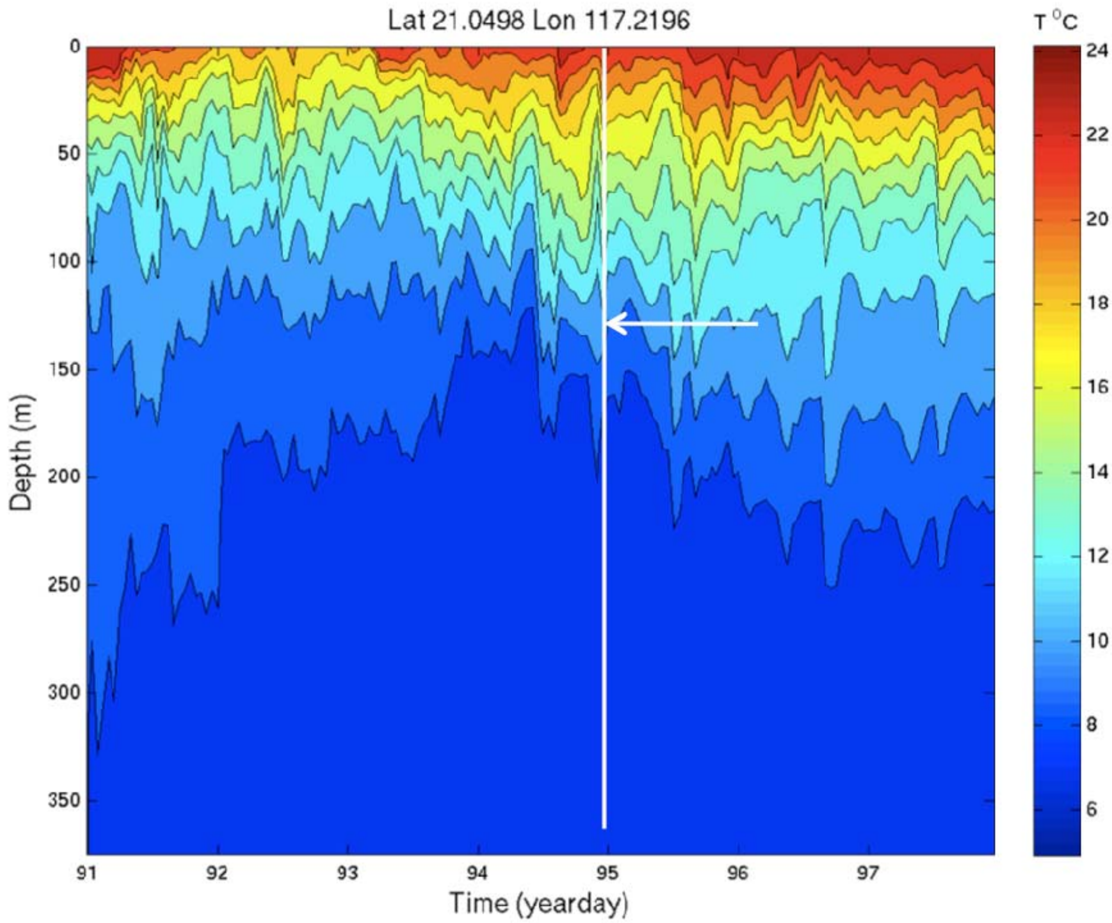

Figure 4. An example of a convex mode 2 NLIW generated by the model hindcast.